tions of differentiation within the cell plasm. In many cells there appears also to be a difference in the character of the cell plasm which immediately surrounds the nucleus and that which lies at and near the periphery of the cell. The peripheral part (ektoplasma) is more compact and gives a definite outline to the cell, although not necessarily differentiating into a cell membrane. The inner part (endoplasma) is softer, and is distinguished by a more distinct granular appearance, and by containing the products specially formed in each particular kind of cell during the nutritive process.

By the researches of numerous investigators on the internal organization of cells in plants and animal, a large body of evidence has now been accumulated, which shows that both the nucleus and the cell plasm consist of something more than a homogeneous, more or less viscid, slimy material. Recognizable objects in the form of granules, threads, or fibers can be distinguished in each. The cell plasm and the nucleus respectively are therefore not of the same constitution throughout, but possess polymorphic characters, the study of which in health and the changes produced by disease will for many years to come form important matters for investigation.

WILLIAM TURNER.

(*To be concluded.*)

EXPERIMENTS OF J. J. THOMSON ON THE STRUCTURE OF THE ATOM.

RECENT ideas as to the stability of the chemical molecule have been much modified by the evidence that it is readily dissociated when a substance is dissolved in water.

The researches now being carried on by J. J. Thomson and his assistants on the electrical conduction of gases seem to require an even more radical and sweeping change in our conception of the structure of the atom itself.

Ordinary gases are perfect non-conductors of electricity of low electromotive force. Electricity may, however, pass through them, more or less readily, under certain conditions, viz:

1. When the electromotive force is sufficient to produce a spark.
2. When the pressure of the gas is much reduced and a sufficient electromotive force is applied; as in a 'vacuum tube.'
3. When the gas is heated very hot, or has been recently in violent chemical activity, as in the region above a flame.
4. When the negative electrode is illuminated by ultra-violet light.
5. When the gas has been very recently exposed to Röntgen rays or to the similar rays proceeding from uranium, radium, etc.

Thomson's investigations on the conduction by sparks through gases at ordinary pressures, indicated that electrolysis took place somewhat as in solutions, and that the amount of decomposition was, in several cases, essentially the same as in the decomposition of solutions. In the case of hot gases and the gases in a vacuum tube, also there was evidence that the conduction was by means of 'ions' or portions of broken-down molecules which acted as carriers for the current.

When an electric current passes through a solution, it is a fundamental law that a univalent atom of any substance carries precisely the same charge as a univalent atom of any other substance, while a bivalent atom carries just twice this charge. The exact charge carried by one atom cannot be known until we know the exact weight of the atom; but the charge carried by 1 gramme of atoms (e/m) is about 10,000 units in the case of hydrogen. For any other univalent substance, the weight required to carry this charge is greater in

proportion as its atoms are heavier than those of hydrogen.

Thomson has undertaken to find the charge carried by the gaseous ion as follows: When the discharge of an induction coil is sent through a vacuum tube, there is seen a luminous glow, stretching in a straight line from the electrode to the wall of the tube. This glow, called the 'cathode ray' would seem to be a stream of negatively charged particles, from the cathode, or negative terminal in the tube, projected in a straight line until some solid obstacle is encountered. This cathode ray, when it meets the tube, or any body in its path, may produce fluorescence; it always produces heating, it also excites the vibrations called by Röntgen the X-ray.

A magnet held near the cathode ray draws it to one side, as if it were a conductor carrying an electric current. Professor Thomson has made use of this property to determine the ratio e/m for the electrified particles. Of course the more strongly the flying particles are charged, the more they will be drawn aside from their rectilinear path, while the heavier the particles, the more nearly would their inertia keep them in a straight line. The ratio of the charge to the mass of a particle determines its velocity at right angles to the original direction.

Again, the flying stream may be drawn aside from its course by an electrified plate at the side of the stream, by which it will be attracted or repelled according as the plate has a positive or negative charge.

Both these methods for deflecting the ray were employed. The energy of the flying particles was also determined from the heat which they produced when directed upon a thermopile; and the ratio of the charge upon the particles to their mass was thus found to be about 10^7, or nearly 1000 times as large as for the hydrogen atom in the electrolysis of solutions.

Again, when ultra-violet light falls upon an amalgamated zinc plate, the gas near the plate becomes conducting. Here again if a magnetic field is produced near the plate, the path of the charged particles is changed. This path can no longer be seen, as in the cathode ray; it may, however, be inferred from the change of conduction, when the distance between the electrodes is varied. The ratio of the charge to the mass of the particles is, in this case, the same as in the cathode ray, as above determined.

If, as is believed, the electric current in these cases consists of a stream of charged particles, we are apparently shut up to the alternative that the charge of each ion is 1000 times as great as is found in solutions, or that the mass of the ions is $\frac{1}{1000}$ as great as that of the hydrogen atom. Probably the former supposition seems much less opposed to our preconceived ideas than the latter, but it is a question to be decided by experiment rather than by preconceived ideas.

To make a direct measurement of the mass of the single ions, or particles taking part in electric conduction, Thomson examined air which had been rendered conducting by exposure to Röntgen rays. The quantity of electricity carried by such air is measured without special difficulty. To count the number of ions taking part in the conduction is quite another matter. This counting has, however, been actually accomplished in the following manner: Damp air, which has been freed from dust by filtering, is exposed to the Röntgen rays and its conductivity determined; it is then suddenly expanded to $1\frac{1}{3}$ times its volume. The expansion and consequent cooling, causes a fine fog or mist to form. It has been found that when such a mist is formed, there is at the center of each drop, a minute particle of dust, or other substance, upon which condensation has taken place. In this case, all the dust had been filtered out,

but the charged ions performed the same duty of allowing condensation to begin, and hence the number of water drops is the same as the number of ions present in the air. To count the number of drops, the weight of the cloud is determined by a sensitive balance. They are also allowed to settle in a bell jar, and the rate of settling is observed. The calculations of Stokes, based upon the viscosity of air, show at what rate drops of different size will fall, and from this, the size of the water drops is determined. The size of the drops and the weight of the cloud give the total number of drops in the cloud, and hence the number of ions present in the air.

The result of this experiment turns out to be that the number of ions, carrying a unit quantity of electricity is perhaps a little less, certainly not very different, from the number carrying a unit quantity in the case of solutions. The other alternative seems to be the true one, that the mass of each ion (or 'corpuscle' as Thomson calls them) has about $\frac{1}{1000}$ the mass of the hydrogen atom. More than this, it seems to be the same for all the gases tried, instead of differing with their atomic weight, indicating that all these gases give off corpuscles of the same mass.

These results, revolutionary as they are, fit in well with some other facts. Thus, the stream of electrified particles constituting the cathode ray, is found to penetrate a mass of air much farther than would be expected if the ray were composed of particles as large as atoms, but just about as far as if they were $\frac{1}{1000}$ as large as hydrogen atoms. They also penetrate all gases in the inverse ratio of their densities. However, if the reason for this is to be found in the fact that their molecules are all built up of corpuscles of the same kind, it must also be true that the structure of the molecules is extremely porous, allowing the corpuscles to pass through them with great freedom.

Further confirmation of this theory is found in a recent discovery by Zeeman in spectrum analysis. When a luminous gas is between the poles of an electromagnet, the lines of its spectrum are found to be affected in such wise as to indicate that the particles whose vibrations produce the light are electrified; and the ratio of the charge to the mass of the particles is found to be the same as for Thomson's 'corpuscles.' Mendeleef, who has grouped the chemical elements into a remarkable series of families, says "the periodic law together with the revelations of spectrum analysis, have contributed again to revive an old, but remarkably long-lived hope, that of discovering * * * the primary matter, which had its genesis in the minds of the Grecian philosophers, and has been transmitted, together with many other ideas of the classic period, to the heirs of their civilization." "From the failures of so many attempts at finding in experiment and speculation, a proof of the compound character of the elements, and of the existence of primordial matter, it is evident, in my opinion, that this theory must be classed among mere Utopias."

It would seem that a beginning has been made in attaining this Utopia. The theory is too new and too extreme to have received the scrutiny and the criticism which it deserves. It yet remains to be seen whether it is consistent with the low internal energy of gaseous molecules, or whether it will prove valuable in explaining the electrical, magnetic or chemical properties of bodies. Its author has already published a number of suggestive 'speculations' as to the part played by corpuscles in electrical and heat conduction, in the Thomson effect, in the magnetism of rotating matter (terrestrial magnetism?) and in a number of the other electrical properties of bodies, which at least indicate some of the possibilities of the new theory in the domain of molecular physics.

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